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"SATURN IN YOUR KITCHEN AND BACKYARD"
Innovative classroom activities on Saturn and the Cassini Mission

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Innovative classroom activities on Saturn and the Cassini Mission

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INTRODUCTION

Over the course of the past few years, the National Aeronautics and Space Administration (NASA) has worked to develop educational programs for students. NASA education specialists are developing a series of educational materials including inquiry-based activities, curriculum supplement materials, and reference materials that aim to introduce students to the excitement of America's space flight program. Collectively termed "education outreach," these programs develop materials for both formal classroom use as well as incorporation into informal education programs such as those at museums and science centers. The Cassini Mission is one of NASA's space flight programs with an established education program.

CASSINI MISSION OVERVIEW

Cassini is one of NASA's robotic spacecraft similar to the Voyager, Galileo, and Magellan missions. Managed for NASA by the Jet Propulsion Laboratory (JPL) of the California Institute of Technology in Pasadena, California, Cassini is currently on the last leg of its interplanetary journey from Earth to Saturn. Cassini is named in honor of the French-Italian astronomer Jean Dominique Cassini (1625-1712) who devoted much of his professional career to studying Saturn. Jean Dominique Cassini accepted a position to help establish the Royal Paris Observatory where he spent the majority of his professional career. While at the observatory, Cassini discovered the Saturnian moons Iapetus, Rhea, Tethys, and Dione. In 1675, he discovered that Saturn's main rings were spilt into two major portions with a gap in between them. That gap, called the Cassini Division, bears his name.

The Cassini spacecraft, which stands over 6.8 meters (22 feet) tall and weighed in at launch at 5,600 kilograms (12,000 pounds), is carrying a fleet of 12 scientific instruments on the orbiter and an atmospheric probe with an additional 6 scientific instruments. This science package is designed to measure many aspects of Saturn, its rings, the planet's magnetic field, its largest satellite Titan, and its 17 smaller satellites. The spacecraft is equipped with imaging instruments in the visible, infrared, and ultraviolet wavelengths to capture different physical phenomena occurring within the Saturn System. Auroras, storms, ring particle composition, and satellite surfaces will all be studied using the instruments. A synthetic aperture radar (SAR) instrument will penetrate Titan's visibly opaque cloud layer, giving planetary scientists a detailed view of the satellite's surface. Two magnetic field instruments will seek to map Saturn's magnetic field in an attempt to better understand the complex relationship between it and the planet, rings, and satellites.

Field and particle instruments will characterize the dust and plasmas present around Saturn. A radio science instrument will use the spacecraft radio and ground antennas to study the compositions, pressures, and temperatures of the atmospheres and ionospheres of Saturn and Titan as well as study Saturn's ring particles and satellite masses.

Figure 1. Cassini Orbiter Instruments

Instrument Name	**Scientific Objective**
Cassini Plasma Spectrometer (CAPS)	Measures composition, density, velocity, and temperature of ions and electrons.
Composite Infrared Spectrometer (CIRS)	Measures infrared emissions from atmospheres, rings, and surfaces.
Cosmic Dust Analyzer (CDA)	Measures flux, velocity, charge, mass, and composition of dust and ice particles.
Imaging Science Subsystem (ISS)	Imaging the atmospheres of Saturn and Titan, the rings of Saturn and their interactions with the planet's satellites, and the surface characteristics of the satellites.
Ion & Neutral Mass Spectrometer (INMS)	Measures neutral species of low-energy ions.
Magnetometer (MAG)	Measures the direction and strength of the magnetic field.
Magnetosphere Imaging Instrument (MIMI)	Images Saturn's magnetosphere using energetic neutral atoms and measures the composition, charge, and energy distribution of energetic ions and electrons.
Cassini Radar (RADAR)	Investigate and image the surface of Titan.
Radio & Plasma Wave Spectrometer (RPWS)	Measures wave emissions as well as electron density and temperature.
Radio Science Instrument (RSS)	Measures the density of Saturn's ionosphere.
Ultraviolet Imaging Spectrograph (UVIS)	Measures ultraviolet emissions to determine sources of plasma in Saturn's magnetosphere.
Visible & Infrared Mapping Spectrometer (VIMS)	Map the surface spatial distribution of the mineral and chemical features of rings, satellite surfaces, and Saturn's and Titan's atmospheres.

In addition to the 12-orbiter instruments, the spacecraft is carrying the Huygens Probe. The Huygens Probe is managed by the European Space Agency (ESA). The probe bears the name Huygens in honor of the Dutch Astronomer Christian Huygens (1625-1695). He was an accomplished astronomer whose career highlights include the discovery of Titan, the discovery of Saturn's rings, and the invention of the pendulum clock (the world's first accurate time keeping device). Huygens was an expert lens crafter and his handmade telescopes contributed greatly to his success at observational discoveries.

Named in honor of the Astronomer, the Huygens Probe will descend through Titan's thick atmosphere and land on the surface. Six scientific instruments will measure atmospheric composition, wind speed and direction, and surface conditions. The Huygens Probe mission will mark the first time in history that a space probe will land on this icy satellite. The unique design of the probe will allow it so survive a solid or liquid landing. From entry into Titan's atmosphere through the lifetime of the probe's battery the mission is slated to last approximately two and one-half hours. The severe cold on Titan will cause the probe's battery to freeze after a couple of hours. All data collected by the probe will be relayed back to the Cassini orbiter overhead. The orbiter will relay the data back to Earth for scientific analysis.

Figure 2. Huygens Probe Instruments

Instrument Name	**Scientific Objective**
Aerosol Collector & Pyrolyzer (ACP)	Captures aerosol particles from Titan's atmosphere.
Descent Imager & Spectral Radiometer (DISR)	Obtains a variety of imaging and spectral observations.
Doppler Wind Experiment (DWE)	Measures the height profile of the zonal wind (along the line of sight) and turbulence in Titan's atmosphere.
Gas Chromatograph & Mass Spectrometer (GCMS)	Provides a quantitative analysis of the composition of Titan's atmosphere.
Huygens Atmospheric Structure Instrument (HASI)	Investigates the physical and electrical properties of Titan's atmosphere.
Surface Science Package (SSP)	Studies the physical properties and composition of Titan's surface.

The spacecraft was launched 15 October 1997 from Cape Canaveral, Florida and will arrive at Saturn on 1 July 2004. The large size of the spacecraft precluded launching it on a direct trajectory to Saturn. In order to achieve the speed necessary to reach the sixth planet, Cassini used the natural gravity of other planets to give the spacecraft a boost. Therefore, Cassini made two planetary flybys of Venus (28 April 1998 and 24 June 1999) and one flyby each of Earth (18 August 1999) and Jupiter (30 December 2000) en route to Saturn. A graphical depiction of Cassini's trajectory is illustrated in figure 3.

Once at Saturn, Cassini will release the Huygens Probe (6 November 2004) where it will make its historic journey through Titan's atmosphere on 27 November 2004. Cassini will remain in orbit around Saturn, making over 70 revolutions in 4 years.

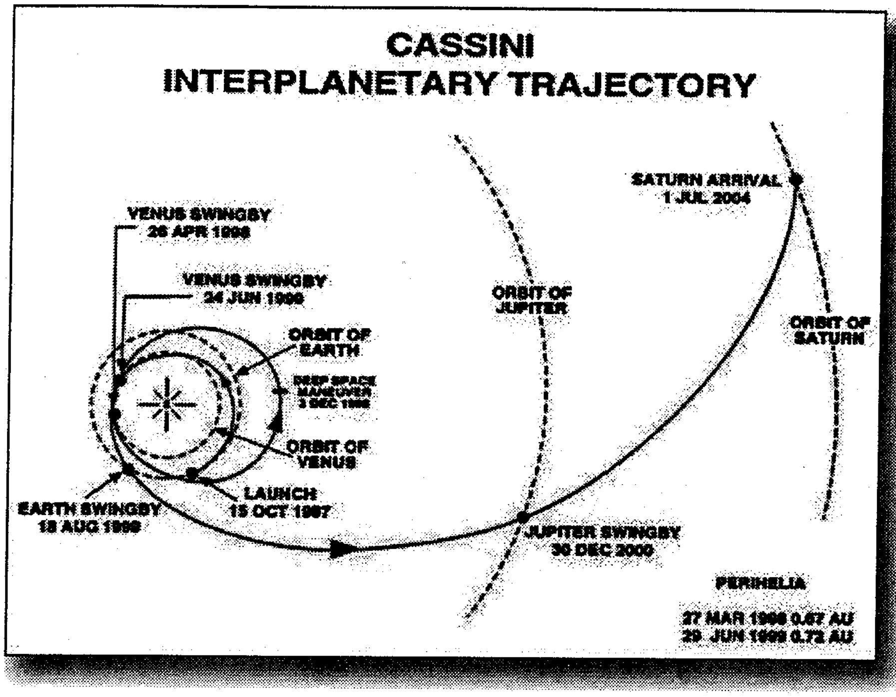

Figure 3. Cassini's trajectory from Earth to Saturn.

CASSINI MISSION EDUCATION OUTREACH

The Cassini Education Outreach Team is dedicated to creating a variety of materials for classroom use as well as informal education venues. Traditional materials such as slide sets, educator guides, posters, fact sheets, and other teaching aids have been the cornerstone of the Cassini Outreach program. The "Saturn In Your Kitchen" program is a unique addition to these traditional materials. In response to an increasing demand by classroom educators for hands-on, inquiry-based science and engineering materials, the Cassini Education Outreach Team has created "Saturn In Your Kitchen and Backyard." This series of activities are aligned with national education standards in math, science, and technology to maximize educator's ability to incorporate them into their curriculum. With the increasing emphasis being placed on standards-based learning, this alignment is crucial to the success of "Saturn In Your Kitchen" classroom educator who is looking for material applicable to specific standards can easily choose activities that will enhance their student's learning.

All activities in the "Saturn In Your Kitchen" program have been field-tested by educators. Many of the activities have been developed by classroom educators working with a scientist or engineer from the Cassini Mission.

Since the creation of the National Aeronautics and Space Administration (NASA), chartered by the Space Act of 1958, NASA has made a substantial commitment to education. NASA's contribution to education has been and is based on the Agency's inspiring mission, specialized workforce, close working relationship with the research and development community, and unique world-class facilities. Based on these unique attributes, NASA has created a comprehensive Education Program containing a portfolio of activities directed toward education at all levels. This comprehensive program contains seven specific initiatives that serve as priority areas for new activities. This program is a comprehensive list that will be carried out by NASA as a whole through the agency-wide programs, the NASA Strategic Enterprise Offices, and programs executed at NASA Field Centers. In summary, the seven initiatives are:

- Focus and coordinate state-based efforts
- Enhance instructional products and dissemination
- Improve education program integration and coordination
- Facilitate NASA research in the higher education community
- Support pre-service education
- Target informal education
- Implement NASA's comprehensive data collection and evaluation system

"Saturn In Your Kitchen" activities are aligned with the NASA education program initiatives. For further details on the NASA education program, please visit the NASA education web site at http://education.nasa.gov/.

SATURN IN YOUR KITCHEN & BACKYARD CONCEPT

The "Saturn In Your Kitchen & Backyard" program is a series of hands-on activities that seeks to introduce students to one of the science or engineering concepts relating to the Cassini Mission. Each activity addresses a specific topic such as light scattering, radar imaging, gravity assist, or spacecraft pointing. Activities teach students the scientific principle, how that principle is being employed on the Cassini spacecraft, and the procedure for classroom experimentation and demonstration. Activities are targeted to the middle school level, grades 5 through 8. However, most activities can be easily geared to students in other grade levels. All "Saturn In Your Kitchen" activities are aligned with the national education standards in math, science, and technology. Included with each activity is a listing of the applicable national education standards for all grade levels.

Activities are designed to introduce topics through hands-on, inquiry based methodology. Using easily available and inexpensive materials such as sand, packing foam, and a standard laboratory thermometer, teachers and students can easily build the experiment and collect data. Students are guided through data collection and analysis. Follow up questions are provided to assess student comprehension. In addition, many activities include extensions that allow students the opportunity for more advanced exploration of the subject.

All activities developed by Cassini Education Outreach for "Saturn In Your Kitchen" are available to download from the Cassini Mission web site at http://www.jpl.nasa.gov/cassini. Activities are grouped by subject and grade level. This allows educators who are looking for specific subject material or grade level material to easily select relevant activities that meet their needs. The Cassini Education Outreach Team is constantly expanding this online database.

Of particular interest to the Cassini Education Outreach Team is the inclusion of activities that not only address the traditional science, math, and technology curricula, but also include materials for students in social sciences, language arts, fine arts, and other liberal arts classes. As standards based education gains emphasis in American schools, classroom educators are finding themselves more time-constrained. Thus, educators are increasingly seeking ways to combine curriculum materials from different disciplines to enhance the quantity of material across different academic subjects. "Saturn In Your Kitchen" activities focused on liberal arts studies seek to introduce the science and engineering of the Cassini Mission and Saturn science into social sciences, fine arts, and other liberal arts activities.

SATURN IN YOUR KITCHEN EXAMPLES

Classroom activities cover a wide range of science, math, and liberal arts subjects. Included here are 2 examples of activities. Each of the examples is focused on a different subject of science or engineering. For the complete text of these, or any other "Saturn In Your Kitchen" activities, visit the Cassini Mission web site at http://www.jpl.nasa.gov/cassini.

Example 1 – Cassini Science Instruments in Action: Light Scattering

This activity demonstrates how light waves passing through a medium are used to determine the sizes of particles within that medium. Our everyday view of the world relies on the reflection of light from the objects around us. This reflection is called backscatter, especially when applied to tiny objects scattering light back to an observer when the light source is behind him or her. Very tiny objects, approximately the size of the source wavelength, also send light forward. The light travels in approximately the same direction of travel as it came from the source, more efficiently than they backscatter light. This effect, called forward scattering, is used by scientists when studying planetary atmospheres and ring systems. The scattering helps to determine the sizes of particles in those environments. Cassini science instruments make use of this scattering principle to study Saturn's rings.

To demonstrate this, the following materials are required:

- Laser pointer
- Two large binder clips
- Two clear plastic or glass water bottles or cups
- Tap water
- Milk or coffee creamer
- Eye dropper
- Flour

- Lazy Susan
- Electrical or masking tape

Adhere a small piece of tape to one side of the container. This will prevent the laser light from passing completely through the bottle and damaging someone's eyes. Fill the first container with water and place it on the lazy Susan. Prepare a very dilute solution of milk, thoroughly mixed so the water is just slightly whitened.

Attach the binder clips to the laser pointer, turning the clips into legs on which to raise the laser pointer. Align the laser to pass through the water container so the beam projects onto the small piece of opaque tape on the far side of the container. Project the laser beam through the container of plain water. Next, repeat this procedure for the dilute milk solution. Notice the difference in laser beam intensity as each container is rotated.

Add a small amount of flour to the container with the plain water. Note the difference between the laser intensity of this solution compared to that of the previous two solutions. Why are the milk and flour solutions so different? Change the water and try adding different solids like other flour grains, masa, cornstarch, or baking powder. Be creative.

Example 2 – Cassini Spacecraft Engineering and Design: Spacecraft Pointing

Cassini is carrying 12 science instruments to Saturn. All 12 of these instruments are "body fixed" which means that in order to point one instrument at Saturn; the entire spacecraft must be turned. This activity is designed to demonstrate how difficult the mission planner's job can become when all 12 of Cassini's instruments want to collect data at the same time.

To demonstrate this activity, the following materials are required:

- A desk chair that swivels
- A board that is wide enough and thick enough to support three people
- A hat, preferably a cowboy, outback, or other brimmed hat
- One small toy telescope
- One pair of binoculars
- A broom handle
- A large drawing or image of Saturn

Place the board on the swivel chair. Find 3 student volunteers. Place the first student volunteer in the center of the board. Place the hat upside-down on top of his/her head. The hat represents Cassini's high gain antenna. Give the student the small telescope and instruct him/her that the telescope can only move up and down. This telescope represents the Magnetospheric Imaging Instrument (MIMI).

With someone holding one end of the board so that it does not tip over, place the second student volunteer on the other end of the board with his/her back to the person in the center. Give the second student the binoculars. These binoculars represent the Imaging

Science Subsystem (ISS). One lens of the binoculars in the wide-angle camera while the other lens is the narrow angle camera. Instruct the student that he/she can only look straight ahead.

Place the third student volunteer on the other end of the board with his/her back toward the person in the center. Give the third student the broom handle and instruct him/her to hold it out in front. The broom handle represents the Magnetometer (MAG).

Now that all three of the students are in position, it's time to take some data. Hang the Saturn image somewhere in the room. The Magnetometer is collecting data on Saturn's magnetic field. Therefore, as long as the instrument is turned on, it does not need to point in any particular direction. The Magnetospheric Imaging Instrument (MIMI) and the Imaging Science Subsystem (ISS) are a whole different story. Since both ISS and MIMI need to actually look at Saturn to collect data, it's obvious that they cannot collect data at the same time. In real mission planning, there is a sequence of events that is pre-defined where one of these instruments will collect data and then the other will have a chance. The excitement comes when both science teams want to collect data at the same time. The mission planning team spends much of its time negotiating observations like these.

Students can suggest strategies such that both instruments can collect data. This activity introduces students to the teamwork and negotiation skills required in space flight operations.